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HIGH REACTANCE TRANSFORMER

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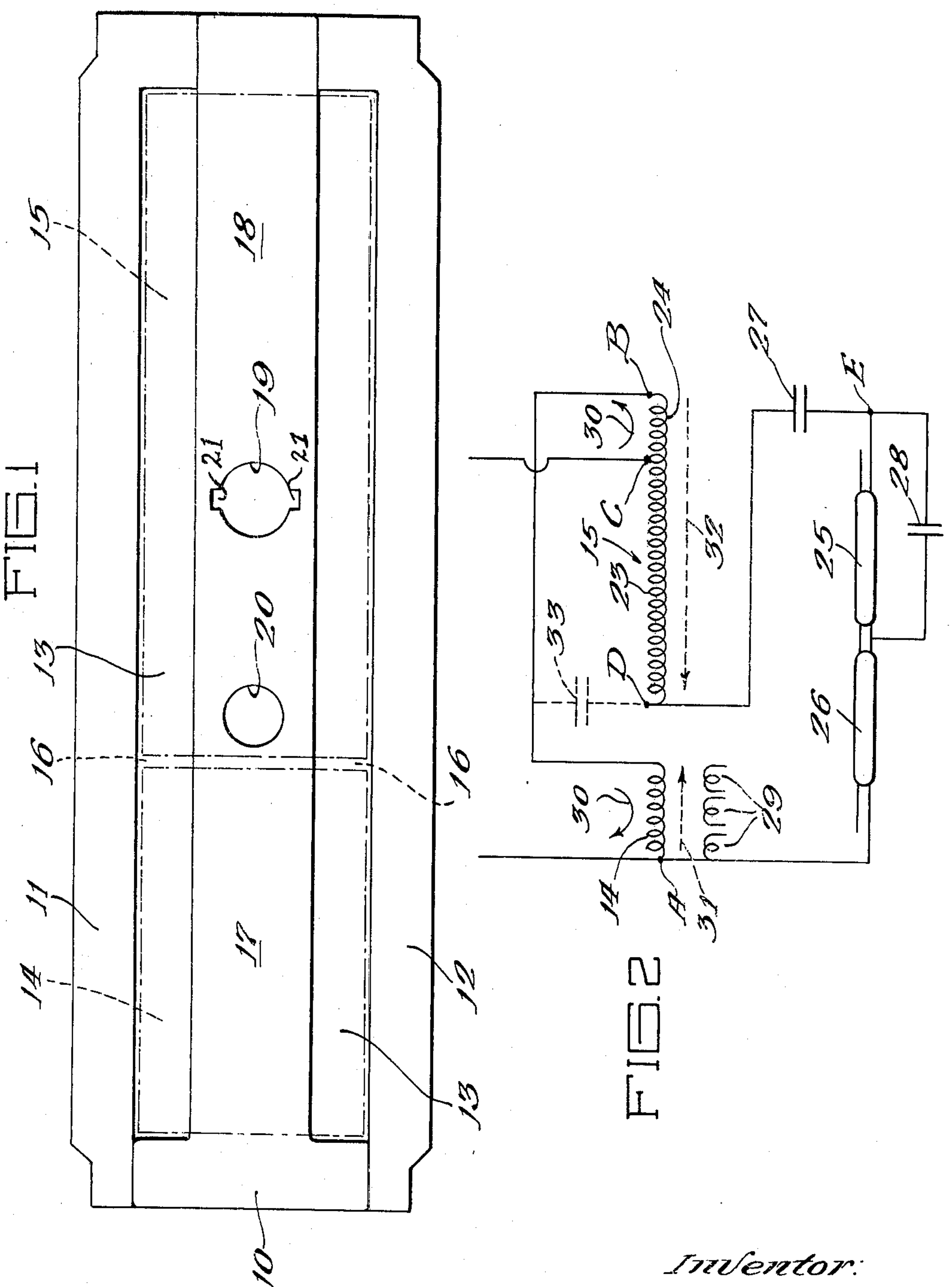

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HIGH REACTANCE TRANSFORMER

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This invention relates to improvements in high reactance transformers, such as those used as ballasts for gaseous discharge lamps in a leading circuit, and in particular to an arrangement which provides an increase in the open circuit voltage without requiring extensive changes in the coil and core structures.

The cross sectional dimensions of a ballast are fixed by arbitrary requirements of the fixture manufacturer, due to the fact that the ballast must fit into a fixture channel which is of standard dimensions. Thus, when it is desired to design a ballast of higher wattage than that provided by a previously designed ballast, it is possible to increase the dimensions of the ballast only in the lengthwise direction. As a result, the length to width proportions of high wattage ballasts increase more or less directly with the desired increase in wattage with respect to a given standard of comparison. However, it has been found that the open circuit voltage does not increase proportionally to the turn ratio in this long and narrow type of ballast, due to leakage which takes place, even on open circuit, across a window which is very long with respect to its width. The length to width ratio of such a window may be as high as 17 to 1, even though the corresponding ratio of the core structure is less than 4 to 1.

It has been proposed to control leakage reactance by making the primary winding in two parts, spaced from each other with the secondary winding in between, and by providing suitable leakage paths at each end of the secondary, which leakage paths are necessary to provide the desired leakage reactance under operating conditions. However, this arrangement frequently calls for the use of shunts, or some other special core structure arrangement to provide the desired leakage at two different places.

According to my invention, I have found that the open circuit voltage can be substantially boosted without providing a special core arrangement to provide for the desired leakage reactance, if only a small portion of the primary winding is located at the remote end of the secondary winding and is closely coupled thereto. According to this arrangement, the leakage path arrangement provided between the main primary coil and the secondary coil, which may be either in the form of a shunt, or coil spacing, or an end-to-end coil arrangement plus slots, is sufficient to provide the desired leakage reactance during operation.

A further advantage of this invention is that the auxiliary primary turns may be in the foim of a tap in the secondary winding, and since the auxiliary primary turns are relatively few in number, the smaller wire size of the secondary winding is sufficient to accommodate the primary current without causing undue temperature rise in that portion of the ballast.

Another object of my invention is to provide a ballast which reduces the tendency of the lamps to flicker which often occurs when the open circuit voltage is not much higher than that required to sustain the arc in the lamps.

Other objects, features, and advantages will appear as the description proceeds.

With reference now to the drawings in which like reference numerals designate like parts:

FIG. 1 is a plan view of a preferred embodiment of my invention showing the core structure of a transformer,

the location of the primary and secondary coils being shown in dotted lines; and

FIG. 2 is an electrical diagram of the circuit of the transformer of FIG. 1.

With reference now to FIG. 1 which shows the core structure of the high reactance transformer, reference numeral 10 designates the winding leg, and the reference numerals 11 and 12 designate the yoke portions. These elements are built up of laminations of the T and L types.

The resulting shell-type core structure provides windows 13 in which the primary coil 14 and the secondary coil 15 are located, as shown in dotted lines. The space between the coils represents a leakage path **16**. The coils are spaced from each other by about one eighth of an inch, and the paper margins represent another one-eighth of an inch each, with the result that the convolutions of the coil are actually separated from each other by about three eighths of an inch. Variation of this distance will affect the leakage reactance, and in some designs, a magnetic shunt type of leakage path may be substituted.

The leakage path 16 divides the winding leg **10** into a primary core portion 17 and a secondary core portion 18. One or more bridged gaps may be located in the secondary core portion 18, and these are preferably in the form of circular gaps 19 and 20. The bridged gaps increase the reluctance of the secondary core portion and thus affect the flux leakage which occurs in the region of the leakage path 16. In the present arrangement, in which the length to width ratio of the windows 13 may be as high as 17 to 1, considerable leakage would ordinarily occur all along the length of the window, but as previously indicated, the coils are connected in such manner as to reduce the leakage which occurs under open circuit conditions.

The circuit is shown in FIG. 2, and it will be observed that the secondary coil **15** is provided with a tap C which divides the coil into two portions **23** and **24**, the latter being referred to as the auxiliary turns **24**. The coil leads are designated B, C, and D. The coil leads of the primary coil 14 are designated A and B. Points A and C are connected to the line, and points A and D are connected to the load.

The load comprises two fluorescent lamps **25** and **26** which are connected in series with each other and in series with an operating condenser **27**. A starting condenser 28 is connected across lamp **25**. Suitable filament windings 29 are connected to the lamp filaments in the conventional manner.

It will be seen from the foregoing, that the primary winding includes the primary coil **14** and the auxiliary turns **24**. The secondary winding comprises all of the turns of the secondary coil **15**, and the secondary circuit includes the primary coil **14** as well.

The curved arrow **30** represents the potential drop of the primary current, whereas the dotted line arrows **31** and **32** represent the direction of induced voltage. The secondary coil **15** is wound in the reverse direction, with respect to the winding direction of primary coil **14**, but the coils are additively connected.

The munber of auxiliary turns **24** represents about twenty to thirty percent of the total primary turns, and the arrangement is preferably such that the tap C can be brought out from the top layer of the secondary coil **15**. By winding the secondary coil in the reverse direction, the turns between points C and B may be physically located at the remote end of the secondary coil. Thus, during open circuit conditions, an auxiliary magnetizing flux is set up in the remote end of the secondary core portion **18** which has been found to be very effective in reducing the amount of leakage which occurs across the windows

13 during open circuit conditions. Nevertheless, the number of auxiliary turns is sufficiently small that it does not materially affect the amount of leakage which occurs during lamp operation. Therefore, according to my invention, a core structure which has been designed to provide the proper amount of leakage for the usual type of coil connection can be used in a transformer made in accordance with the arrangement shown in FIG. 2.

A commercial embodiment of my invention, suitable for energizing two 72-inch rapid start lamps, was constructed according to the following:

The primary coil 14 comprised 266 turns of No. 18 wire.

The secondary coil 15 comprised 1323 turns of No. 19½ wire arranged in nine layers of 147 turns per layer. The last 70 turns of the top layer were tapped off, to provide the auxiliary turns 24. The secondary coil was about 6⅜ inches long, so that the auxiliary primary 24 was distributed over the remote 2½ inches of the secondary coil.

The core structure was approximately 9½ inches long and 3 inches wide, and the stack was 1⁷⁄₁₆ inches high. The yokes, 11 and 12, were ½ inch wide and the winding leg 10 was 1 inch wide. The windows 13 were approximately 8½ inch long and ½ inch wide.

The operating condenser 27 was 8.0 mfd., and the starting condenser 28 was .09 mfd. The lamps were type 72T17 P.G.

The circular gap 19 was ⅝ inch in diameter, and the circular gap 20 was ½ inch; they were located approximately at the 50 percent and 20 percent points of the secondary core portion 18, measuring from the center line of the flux leakage path 16 to the remote end of the window 13. The opening 19 had notches 21, each 1⁄16 inch deep, so that the total length of the circular gap 19 was ¾ inch.

When the primary winding, 14–24, is connected to a 120 volt 60 cycle line, the current in the secondary circuit is 1.66 amps. The line current is 3.26 amps. Power factor is 91 percent, and light is 100% (ASA test).

The voltage drops across points A, B, C, D, and E during lamp operation are as follows:

AB	95
AC	120
AD	580
AE	249
BC	29
BD	496
BE	205
CD	469
CE	209
DE	528

The open circuit voltage across points AD is 460 and has a crest factor of 1.78.

The starting voltage of type 72T17 lamps is approximately 445 volts, and the rated operating voltage is 128 at 1.5 amps.

When a resonant condenser 33 of .33 mfd. is connected across points B and D as shown in FIG. 2, the identical ballast will start and operate two 96-inch rapid start lamps, type 96T17 P.G., the characteristics of which are:

Starting voltage	555
Operating voltage	172
Operating current	1.5

Preferably, an operating condenser of 8.9 mfd. is used with 96 inch lamps.

It will be observed from the foregoing that with this type of long narrow core structure, the open circuit voltage of 460 is considerably less than the turn ratio voltage of 593. If the primary winding were not split, as indicated herein, the open circuit voltage would be about 425 volts, which is insufficient to start a 72 inch lamp. The arrangement of my invention increases the open circuit voltage by at least 8% without requiring redesign of the core structure or adjustment of the turn ratio.

Also, my invention materially reduces the tendency to lamp flicker which is a serious problem when higher wattage ballasts are designed to standard channel dimensions.

It will be understood that the core and coil structure is potted and enclosed in a steel casing in the usual manner, together with the condensers.

Other arrangements may be provided in which it is not necessary to reverse the winding direction of the secondary coil, but the FIG. 2 embodiment is preferred from the viewpoint of cost because it permits the use of a tap instead of a separate coil of 70 turns.

For instance in one such arrangement the auxiliary turns may be in the form of a small, narrow coil located at the remote end of the secondary coil and closely coupled thereto, but not included in the secondary circuit. The uniform winding direction permits the usual end-to-end type of auto-transformer connection between the primary and secondary coils.

The characteristic of the resonant or harmonic condenser 33 is that a relatively high volatge drop is developed across it at harmonic frequencies, such as the third or fifth harmonic, which voltage drop cooperates with the voltage boost provided by the auxiliary turns 24 to provide the higher starting voltage required by the 96 inch lamps.

Although only a preferred embodiment of my invention is shown and described herein, it will be understood that various modifications and changes may be made in the construction shown without departing from the spirit of my invention as pointed out in the appended claims.

I claim:

1. A high reactance transformer for use in energizing a leading lamp load of the gaseous discharge type comprising a core having a winding leg and a yoke cooperating with each other to provide a long narrow window, primary and secondary coils located side by side on said winding leg, a plurality of auxiliary turns located at that end of said secondary coil which is remote with respect to said primary coil, and means connecting said auxiliary turns in series with said primary coil to provide a primary winding which includes said primary coil and said auxiliary turns, said secondary coil being connected in auto-transformer relationship to said primary coil, said primary and secondary coils being loosely coupled to each other to provide high leakage reactance during lamp operation, and said secondary coil and said auxiliary turns being tightly coupled to each other.

2. A high reactance transformer as claimed in claim 1 in which said secondary coil is reversely wound with respect to said primary coil, and said auxiliary turns represent a tapped portion of said secondary coil.

3. A high reactance transformer as claimed in claim 2 in which said tapped portion is located entirely in the outer layer of said secondary coil and comprises substantially 25 percent of the turns of said primary coil.

4. A high reactance transformer as claimed in claim 1 in which the turn ratio of said primary winding to said secondary coil is substantially one to four.

5. A high reactance transformer as claimed in claim 1 in which the length to width proportions of said window are substantially seventeen to one.

6. A high reactance transformer as claimed in claim 1 in which said winding leg includes a bridged gap formed in the secondary portion thereof.

7. A high reactance transformer for use in energizing a leading lamp load of the gaseous discharge type comprising a core having a winding leg and a yoke cooperating with each other to provide a long narrow window, primary and secondary coils located side by side on said winding leg to provide loose coupling therebetween, a plurality of auxiliary turns closely coupled to said secondary coil, and means connecting said auxiliary turns

in series with said primary coil to provide a primary winding which includes said primary coil and said auxiliary turns, said auxiliary turns representing less than 30% of the total primary winding turns, and said secondary coil being connected in auto-transformer relationship to at least a portion of said primary winding.

8. A ballast for energizing a fluorescent lamp load including a high reactance transformer and a series connected operating condenser, said high reactance transformer comprising an elongate type core structure having a winding leg and oppositely disposed yokes, primary and secondary coils disposed on said winding leg in side by side relationship, a bridged gap formed in said winding leg at a point wherein it is completely surrounded by said secondary coil, said secondary coil being tapped to provide an auxiliary turns portion which is located at the remote end of said secondary coil, said auxiliary turns portion being additively connected to said primary coil to provide a primary winding, lead means connecting said secondary coil to said primary winding in auto-transformer relationship to provide a secondary winding, a fluorescent lamp load means including said series connected operating condenser for connecting said secondary winding to a fluorescent lamp load to provide a secondary circuit, and a harmonic condenser connected across said secondary coil.

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